

State of New Hampshire
Inter-Department Communication

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From: Kenneth Edwardson,
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At (Office):
Environmental Services
Watershed Management

Subject: Probabilistic Assessments of Water Quality in New Hampshire's Lake Waters

To: Kenneth Edwardson, Water Quality Assessment Program Coordinator

**Comprehensive Assessment of New Hampshire Lakes
for 305(b) Designated Use Support Determinations
2010**

Executive Summary

Fifty randomly-selected New Hampshire lakes were sampled in 2007 through 2009 and were assessed for designated use support using the 2010 CALM criteria. All lakes fully supported the swimming use based on the pathogen indicator *E. coli* and 95% of the lakes fully supported the swimming use based on all assessment parameters. Only four percent of the lakes fully supported the aquatic life use. The largest cause of not support for aquatic life was pH (84%) followed by nutrients (chlorophyll and phosphorus, 56%). All lakes fully supported the secondary contact recreational use.

Introduction

New Hampshire participated in the National Lake Assessment (NLA) surveys in 2007, sampling 13 randomly-selected New Hampshire lakes. The data collected was part of the national report (1) on the status of the nation's lakes. Additional lakes were sampled in 2008 and 2009 such that 50 randomly-selected NH lakes were sampled according to NLA protocols (1). The chemistry results and biological samples were submitted to EPA-Region 1 for use in the regional New England Lakes and Ponds (NELP) analysis by EPA-Narragansett.

While the original survey design was intended to report on the numbers of lakes that do or do not meet water quality criteria in the spring of 2011 EPA produced a series of 'R' scripts to convert the probabilistic estimates from counts of waters to acreage of waters. The primary focus of this document is lakes as discrete resources and as such the counts of lakes assessed in a given category is given precedence over acreage.

Only data used to assess designated uses were used in the analysis for this report. The designated uses assessed included the primary contact recreation (PCR) or swim use, the secondary contact recreation (SCR) or boating/fishing use and the aquatic life use. Parameters used to assess PCR use were *E. coli*, chlorophyll and the presence of a visible Cyanobacteria scum. The SCR use was assessed using *E. coli* only. Aquatic life use was

assessed using pH, dissolved oxygen (both percent saturation based on a daily average and an instantaneous minimum), nutrients (chlorophyll and total phosphorus), presence of exotics, and alkalinity. The criteria thresholds for determining support or non support for these parameters are outlined in New Hampshire's Consolidated Assessment and Listing and Methodology (CALM). (2)

Methods

Lakes were sampled once during the summer months according to NLA protocols. A two meter composite sample was collected for chemical analyses and a multi-metric probe was used to collect profile data. Additional samples were collected according to NH Department of Environmental Services (DES) lake trophic survey protocols and, in rare instances, this data supplemented the NLA data (see Appendix A for data conventions).

The 50 lakes were selected by a random draw stratified by lake surface area. The stratification was done to allow for all lake sizes to be sampled. A truly random draw would have selected mostly small ponds since small ponds greatly exceed larger lakes in number. The lake categories were 4 to 10, 10 to 20, 20 to 50, 50 to 100 and > 100 hectares. A total of 1,004 New Hampshire lakes representing 185,272.4 acres of lakes and lake-like waterbodies were in the pool from which the 50 lakes were selected. The lakes were given a weight based on their size because, for example, a 5 hectare lake represents many more lakes than a 100 hectare lake (i.e., more lakes in the size category). The final analysis requires the assessment results to be weighted such that the results for a given lake represents the results for all the lakes in the given size category.

Results:

Assessment results expressed as the percent of lakes along with lower and upper confidence limits for each of the individual parameters and for the final assessments for primary contact and aquatic life uses are listed in Appendix C. The listing convention is FS (full support), NS (not support), PNS (potentially not support), PAS (potentially attaining support) and II (insufficient information). The latter three categories reflect insufficient information to assess the use and are explained in the previously referenced CALM (2). The secondary contract recreation use is not listed in the table because 100% of all lakes support this designated use. The table below summarizes the final assessments for the primary contact and aquatic life uses.

Designated Use	Assessment	Percent of Lakes (by count)	Number of Lakes (> 10 acres)	Percent of lake area (by acreage)	Acres of Lakes
primary contact	full support	95.3%	957	98.6%	182,635
primary contact	not support	4.7%	47	1.4%	2,637
aquatic life	full support	3.8%	38	2.7%	4,969
aquatic life	not support	96.2%	966	97.3%	180,303

Primary Contact Recreation

The causes of not support for the primary contact use were high chlorophyll values (3.7% by count, 0.7% by acreage) and the presence of a cyanobacteria scum (0.9% by count, 0.7% by acreage). All New Hampshire lakes fully supported primary contact based on the *E. coli* criterion.

Secondary Contact Recreation

All lakes fully supported the SCR use. This information is not presented in Appendix C.

Aquatic Life Use

The percent of lakes in each of the aquatic life use assessment criteria are summarized in the tables below. The final column lists the final assessments for aquatic life. Clearly lakes may be not supporting by more than one parameter. The totals in each column may not equal 100 percent because of rounding.

Percentage in each assessment category by count of lakes

	DO	% Sat	pH	Chl	TP	Exotics	ANC	ALU
FS	88.0	47.9	16.0	44.0	38.4	83.9		3.8
NS	9.5	15.7	84.0	56.0	56.0	16.1		96.2
PAS							4.7	
PNS					5.6		95.3	
II	2.5	36.3						
Total	100	99.9	100	100	100	100	100	100

Percentage in each assessment category by area of lakes

	DO	% Sat	pH	Chl	TP	Exotics	ANC	ALU
FS	95.3	87.6	5.4	78.3	74.9	36.0		2.7
NS	4.2	5.1	94.6	21.7	21.7	64.0		97.3
PAS							0.7	
PNS					3.5		99.3	
II	0.5	7.2						
Total	100	99.9	100	100	100	100	100	100

By Counts - Less than four percent of New Hampshire lakes fully support the aquatic life use. Assessment criteria are strictly based on water quality criteria (3). For example, the pH criterion is 6.5 to 8.0 unless due to natural causes, and low pH values were the main cause for the not support assessments (84%). The worst case pH value encountered on the sampling date, including all but the very bottom profile value, was selected as required by the CALM, and if the lowest value was below pH 6.5, the lake was assessed as non support. Nutrients as represented by phosphorus and the response indicator chlorophyll were the second greatest cause for not support (56%). Exotic weeds were the third greatest cause for not support (16%). As indicated in the CALM, the threshold criteria for phosphorus and chlorophyll assessments were based on the trophic class of the lake. For example, an oligotrophic lake would be assessed as non support for aquatic

life if the median phosphorus value equaled or exceeded 8 ug/L or the median chlorophyll equaled or exceeded 3.3 ug/L (see table below).

	TP (ug/L)	Chl (ug/L)
oligotrophic	< 8.0	< 3.3
mesotrophic	<= 12.0	<= 5.0
eutrophic	<= 28	<= 11

By Area - Less than three percent of New Hampshire lakes fully support the aquatic life use. Assessment criteria are strictly based on water quality criteria (3). For example, the pH criterion is 6.5 to 8.0 unless due to natural causes, and low pH values were the main cause for the not support assessments (94.6%). The worst case pH value encountered on the sampling date, including all but the very bottom profile value, was selected as required by the CALM, and if the lowest value was below pH 6.5, the lake was assessed as non support. Exotic weeds were the second greatest cause for not support (64%). Nutrients as represented by phosphorus and the response indicator chlorophyll were the third greatest cause for not support (21.7%).

References

- (1) <http://www.epa.gov/owow/lakes/lakesurvey/>
- (2) <http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm>
- (3) <http://des.nh.gov/organization/commissioner/legal/rules/documents/env-wq1700.pdf>

Appendix A

Decisions & Conventions used in the Assessment of New Hampshire Lakes for 2010

1. Adder Pond was the first and last lake sampled in 2007 and was sampled in 2008 and 2009, all for QA purposes. The last 2007 sample results (August – worst case) were used for assessments.
2. Lake Wicwas was the first and last lake sampled in 2009. Last date sampled in 2009 (August) was used for assessments.
3. An exception to the use of NLA protocols is the pathogen indicator. *E. coli* was used as the indicator and not the NLA protocol indicator *Enterococci*. The greater

- value of the two samples collected on the sampling day was used for the single sample maximum (SSM). In most cases the lakes were sampled on two additional dates to collect one *E. coli* sample on each day in order to calculate a 60-day geomean (GM). All samples collected within 60 days were used in the GM calculation, a 'less than' value was listed as one-half the detection limit, and a value of 0 cnts/100 mL was listed as 0.01 cnts/100 mL (all per ADB protocol).
4. The PCR use was assessed as impaired because of a cyanobacteria scum only if a scum was present at the time of the survey. This was true even if a lake with no scum at survey time was posted later in the season because of cyanobacteria. This protocol was followed to ensure that all lakes were treated equally.
 5. The same principle as applied in # 4 above was applied to exotics and ALU. Lakes were impaired for aquatic life because of exotics only if the exotics were observed during the survey. (note: exotic macrophytes are not as ephemeral as cyanobacteria scums; exotics were observed in all lakes known to have exotics).
 6. In 2007, chlorophyll (2 m composite) samples were analyzed by an EPA contract lab and by DES. The DES values were used to maintain consistency with the 2008-09 chlorophyll samples that were run by DES only. An exception was the 8/30/2007 Adder Pond chlorophyll where no DES value was available; the contract value was used. (note: glass fiber filters were used for NLA chlorophyll analyses and nitro-cellulose membrane filters for DES analyses).
 7. The 2m composite TP sample for Baboosic Lake (2008) was not analyzed; we used the 2 m grab sample for TP.
 8. pH was evaluated using both the 2m composite sample and the profile data, with the bottom pH value from the profile data deleted because of sediment/water interactions. The lowest (worse case) value of the remaining values was used in the assessment. Color was not used – all pH values were considered not natural.
 9. An exception to above is that the electronic copy of profile data for Otter and Sunset Lakes (both 2008) were missing and no hard copy was available. The 3 discrete samples from the trophic survey data were used for the assessments of pH. The 2008 VLAP profiles were used for the assessment of dissolved oxygen and percent saturation.

Appendix B

Designated Use Level Comprehensive Assessment of New Hampshire Lakes

Table B1: Summary of Aquatic Life Use Support in NH's Lakes (by count)

Category	Percent	Lower CI*	Upper CI*	Lakes
Fully Supporting	3.8%	0.0%	8.1%	38
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	96.2%	91.9%	100.0%	966
Not Assessed	0.0%	0.0%	0.0%	0
Total	100.0%			1004

* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

Table B2: Summary of Aquatic Life Use Support in NH's Lakes (by area)

Category	Percent	Lower CI*	Upper CI*	Lake Acres
Fully Supporting	2.7%	0.0%	6.1%	4,969
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	97.3%	93.9%	100.0%	180,303
Not Assessed	0.0%	0.0%	0.0%	0
Total	100.0%			185,272

* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

Table B3: Section 305(b) Reporting Data Elements for Aquatic Life Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Aquatic Life Use Support
Indicator	pH, dissolved oxygen (both percent saturation based on a daily average and an instantaneous minimum), nutrients (chlorophyll and total phosphorus), presence of exotics, and alkalinity
Size	1,004
Units	Lakes
Number of sites	50 Lakes
Percent attaining	3.8%
Percent insufficient information	0.0%
Percent not attaining	96.2%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-4%

Table B4: Section 305(b) Reporting Data Elements for Aquatic Life Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Aquatic Life Use Support
Indicator	pH, dissolved oxygen (both percent saturation based on a daily average and an instantaneous minimum), nutrients (chlorophyll and total phosphorus), presence of exotics, and alkalinity
Size	185,272 acres
Units	Lakes
Number of sites	50 Lakes
Percent attaining	2.7%

Percent insufficient information	0.0%
Percent not attaining	97.3%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-3%

Figure 1: Summary of Aquatic Life Use Support in NH's Lakes (percent by count)

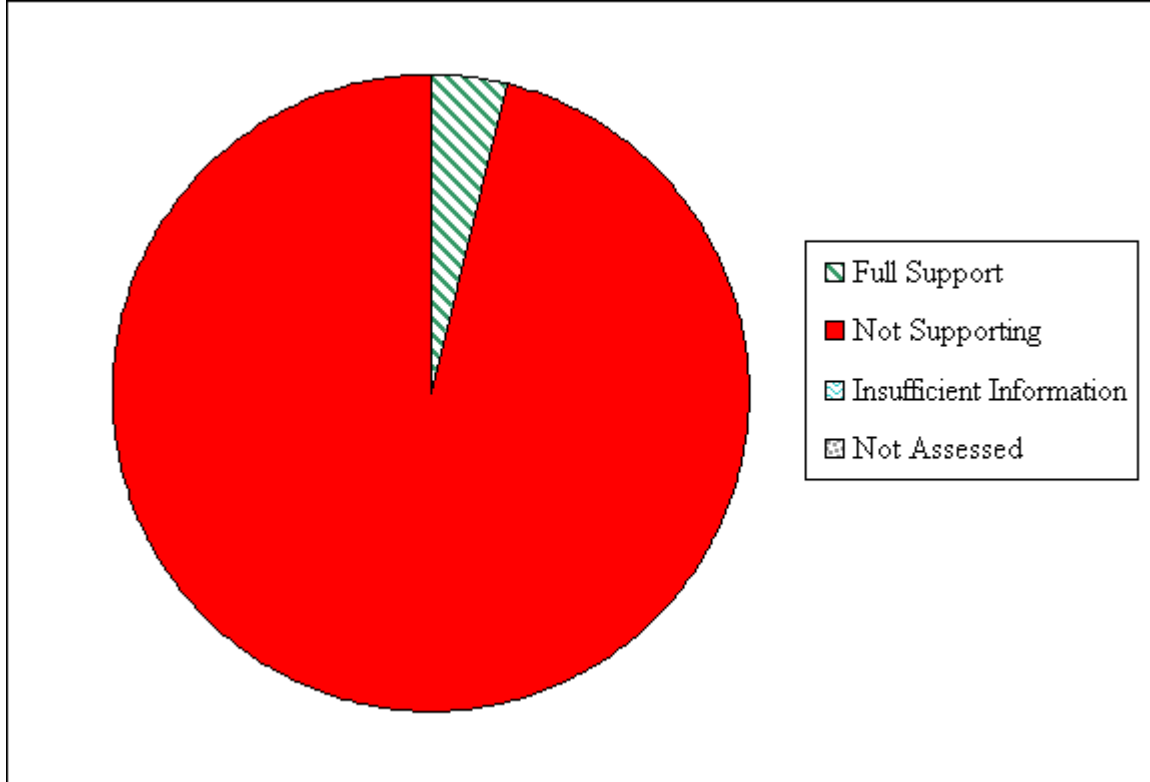


Table B5: Summary of Primary Contact Recreation (i.e. Swimming) Use Support in NH's Lakes by Count

Category	Percent	Lower CI*	Upper CI*	Lakes
Fully Supporting	95.3%	87.6%	100.0%	957
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	4.7%	0.0%	12.4%	47
Not Assessed	0.0%	0.0%	0.0%	0
Total	100.0%			1004

* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

Table B6: Summary of Primary Contact Recreation (i.e. Swimming) Use Support in NH's Lakes by Area

Category	Percent	Lower CI*	Upper CI*	Lakes
Fully Supporting	98.6%	96.6%	100.0%	182,635
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	1.4%	0.0%	3.4%	2,637
Not Assessed	0.0%	0.0%	0.0%	0

Total	100.0%		185,272
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* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

Table B7: Section 305(b) Reporting Data Elements for Primary Contact Recreation (i.e. Swimming) Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Primary Contact Recreation
Indicator	<i>E. coli</i> , chlorophyll and the presence of a visible Cyanobacteria scum
Size	1,004
Units	Lakes
Number of sites	50 Lakes
Percent attaining	95.3%
Percent insufficient information	0.0%
Percent not attaining	4.7%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-6%

Table B8: Section 305(b) Reporting Data Elements for Primary Contact Recreation (i.e. Swimming) Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Primary Contact Recreation
Indicator	<i>E. coli</i> , chlorophyll and the presence of a visible Cyanobacteria scum
Size	185,272 acres
Units	Lakes
Number of sites	50 Lakes
Percent attaining	98.6%
Percent insufficient information	0.0%
Percent not attaining	1.4%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-2%

Figure 2: Summary of Primary Contact Recreation (i.e. Swimming) Use Support in NH's Lakes (percent by count)

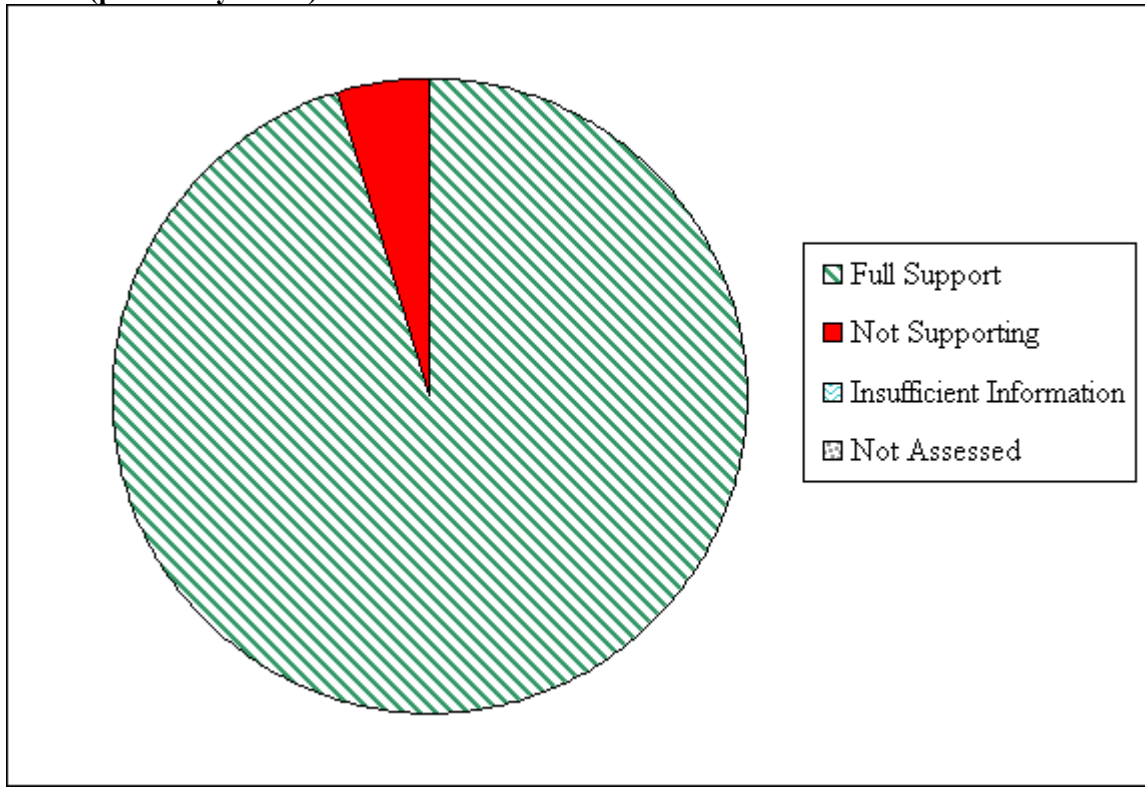


Table B9: Summary of Secondary Contact Recreation (i.e. Boating) Use Support in NH's Lakes by Count

Category	Percent	Lower CI*	Upper CI*	Lakes
Fully Supporting	100.0%	100.0%	100.0%	1004
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	0.0%	0.0%	0.0%	0
Not Assessed	0.0%	0.0%	0.0%	0
Total	100.0%			1004

* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

Table B10: Summary of Secondary Contact Recreation (i.e. Boating) Use Support in NH's Lakes by Area

Category	Percent	Lower CI*	Upper CI*	Lakes
Fully Supporting	100.0%	100.0%	100.0%	185,272
Insufficient Information	0.0%	0.0%	0.0%	0
Not Supporting	0.0%	0.0%	0.0%	0
Not Assessed	0.0%	0.0%	0.0%	0
Total	100.0%			185,272

* Lower and Upper CI: Lower and upper bounds of the 95th percentile confidence limits of the percentage.

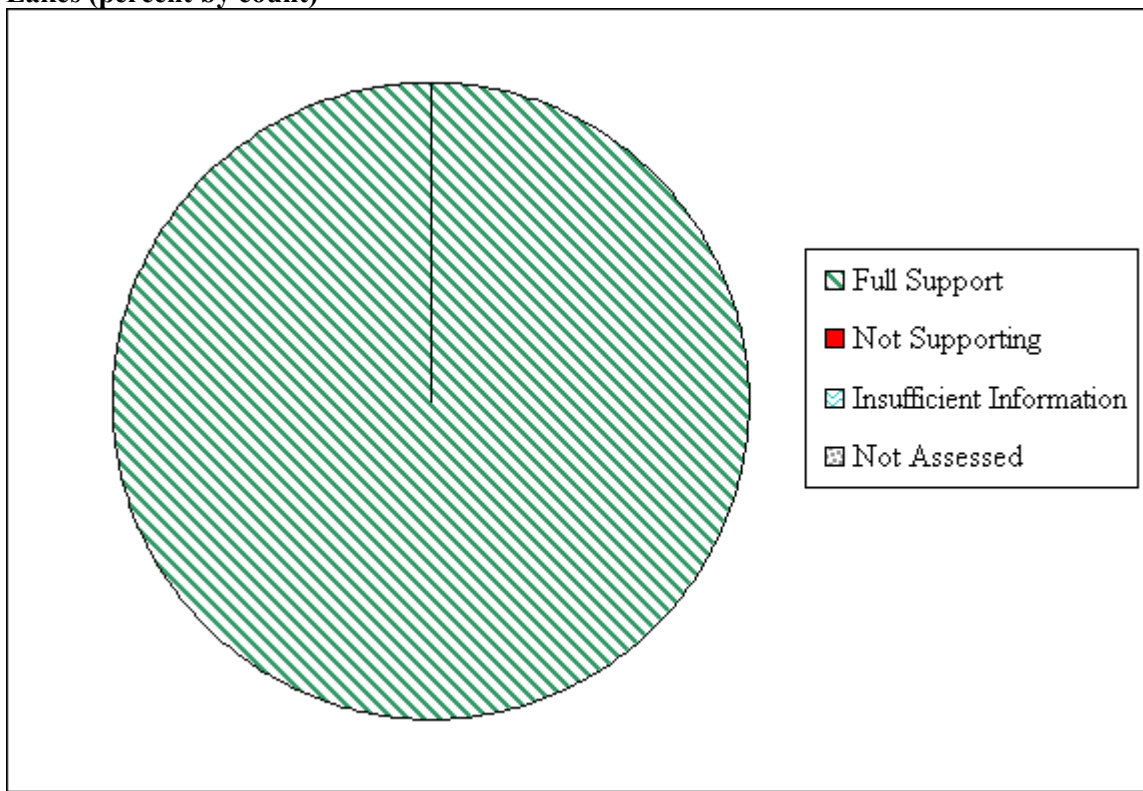
Table B11: Section 305(b) Reporting Data Elements for Secondary Contact Recreation (i.e. Boating) Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Secondary Contact Recreation
Indicator	<i>E. coli</i>
Size	1,004
Units	Lakes
Number of sites	50 Lakes
Percent attaining	100.0%
Percent insufficient information	0.0%
Percent not attaining	0.0%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-0%

Table B12: Section 305(b) Reporting Data Elements for Secondary Contact Recreation (i.e. Boating) Use Support

Data Element	Result
Probabilistic Network Name	New Hampshire Lake Assessment
Project ID (Assessment Unit ID)	1,004 Lakes
Target Population	NH's Lake resources
Resource Type	Lakes
Designated Use	Secondary Contact Recreation
Indicator	<i>E. coli</i>
Size	185,272 acres
Units	Lakes
Number of sites	50 Lakes
Percent attaining	100.0%
Percent insufficient information	0.0%
Percent not attaining	0.0%
Data	2007, 2008, & 2009 data for water quality
Confidence	+/-0%

Figure 3: Summary of Secondary Contact Recreation (i.e. Boating) Use Support in NH's Lakes (percent by count)



Appendix C
Parameter Level Comprehensive Assessment of New Hampshire Lakes by Count

Parameter	Classification	Percent of Lakes	Lower Confidence Limit	Upper Confidence Limit
ALU	FS	3.8	0.0	8.1
ALU	NS	96.2	91.9	100.0
ANC	PAS	4.7	0.0	12.4
ANC	PNS	95.3	87.6	100.0
Chl (ALU)	FS	44.0	18.3	69.7
Chl (ALU)	NS	56.0	30.3	81.7
CHL (PCR)	FS	96.3	88.8	100.0
CHL (PCR)	NS	3.7	0.0	11.2
CYANO	FS	99.1	97.2	100.0
CYANO	NS	0.9	0.0	2.8
DO	FS	88.0	75.6	100.0
DO	II	2.5	0.0	7.5
DO	NS	9.5	0.0	20.7
DOSAT	FS	47.9	20.6	75.3
DOSAT	II	36.3	2.6	70.0
DOSAT	NS	15.7	1.1	30.4
E.COLI	FS	100.0	100.0	100.0
E.COLI	NS	0.0	0.0	0.0
EXOTICS	FS	83.9	70.2	97.7
EXOTICS	NS	16.1	2.3	29.8
PCR	FS	95.3	87.6	100.0
PCR	NS	4.7	0.0	12.4
PH	FS	16.0	1.6	30.4
PH	NS	84.0	69.6	98.4
TP	FS	38.4	15.0	61.8
TP	NS	56.0	30.3	81.7
TP	PNS	5.6	0.3	10.9

Parameter Level Comprehensive Assessment of New Hampshire Lakes by Area

Parameter	Classification	Percent of Lakes	Lower Confidence Limit	Upper Confidence Limit
ALU	FS	2.7	0.0	6.1
ALU	NS	97.3	93.9	100.0
ANC	PAS	0.7	0.0	1.9
ANC	PNS	99.3	98.1	100.0
Chl (ALU)	FS	78.3	60.7	95.9
Chl (ALU)	NS	21.7	4.1	39.3
CHL (PCR)	FS	99.3	98.0	100.0
CHL (PCR)	NS	0.7	0.0	2.0
CYANO	FS	99.3	98.0	100.0
CYANO	NS	0.7	0.0	2.0

Parameter	Classification	Percent of Lakes	Lower Confidence Limit	Upper Confidence Limit
DO	FS	95.3	89.9	100.0
DO	II	0.5	0.0	1.4
DO	NS	4.2	0.0	9.4
DOSAT	FS	87.6	76.7	98.6
DOSAT	II	7.2	0.0	14.4
DOSAT	NS	5.1	0.0	10.8
E.COLI	FS	100.0	100.0	100.0
E.COLI	NS	0.0	0.0	0.0
EXOTICS	FS	36.0	9.2	62.7
EXOTICS	NS	64.0	37.3	90.8
PCR	FS	98.6	96.6	100.0
PCR	NS	1.4	0.0	2.0
PH	FS	5.4	0.3	10.5
PH	NS	94.6	89.5	99.7
TP	FS	74.9	54.8	94.9
TP	NS	21.7	4.1	39.3
TP	PNS	3.5	0.0	7.2